Implementation of AI in the Services Layer of a Morbidity Reporting Application

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ITI

Part I – The Ontology

- Steps –
  - Define the domain
  - Build the model
  - Select the vocabulary domains and value sets
  - Build the ontology model
  - Populate the ontology
  - Bind the value sets to the case definitions
  - Develop the metaclasses to define the rule sets

Protégé

- An Open Source Ontology Editor
- Developed and maintained by Stanford
- Funded by DARPA, NCI
- Frame based
- OWL extensions
- PAL Query Language
- Java API

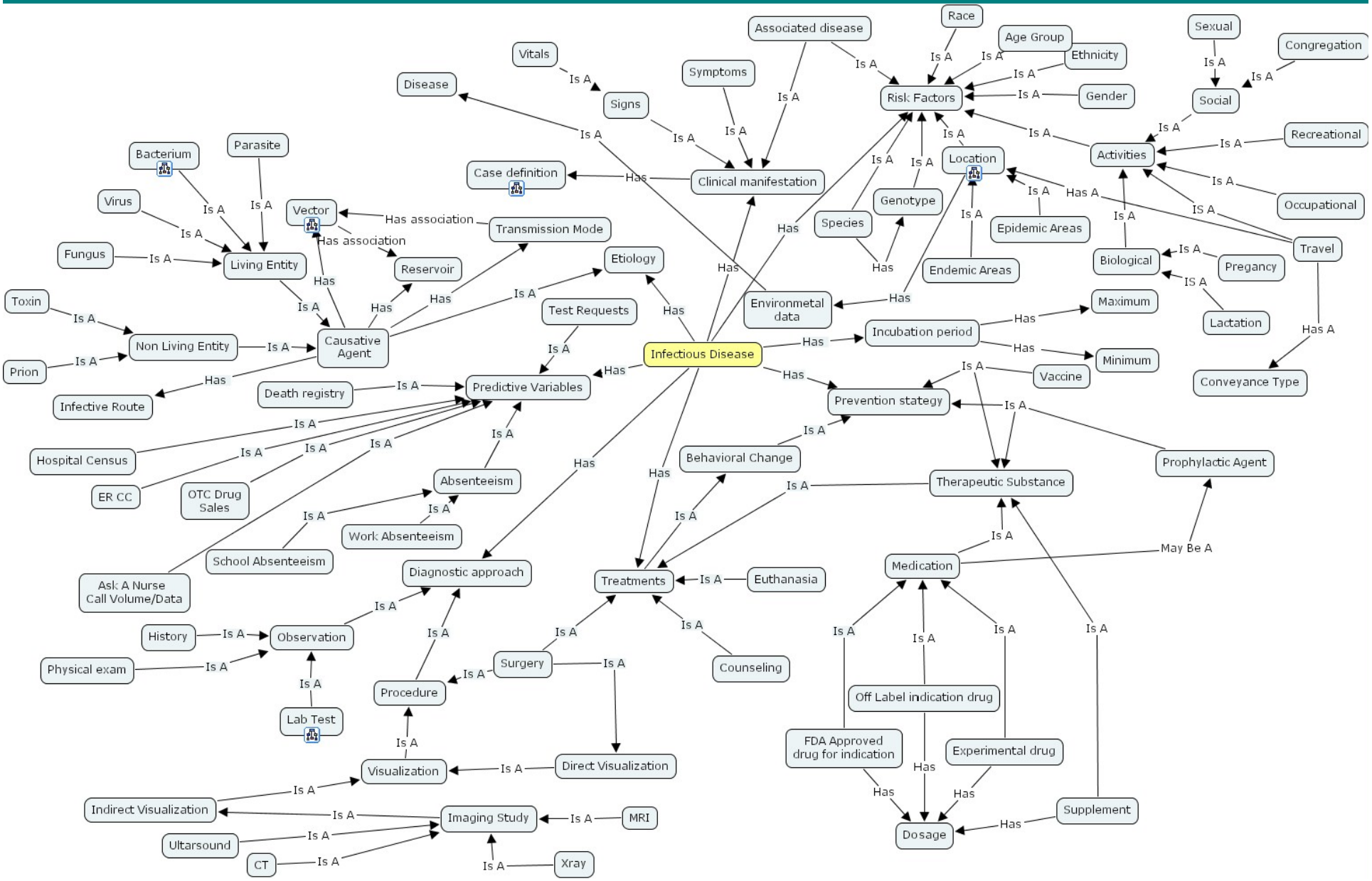
What's in the KB

- Standards based
  - CHI Vocabulary
    - LOINC for lab test
    - SNOMED for clinical observations
    - HL7 for data types
    - HL7 Version 3 structural codes
    - Translational mappings to ICD-9, UMLS,

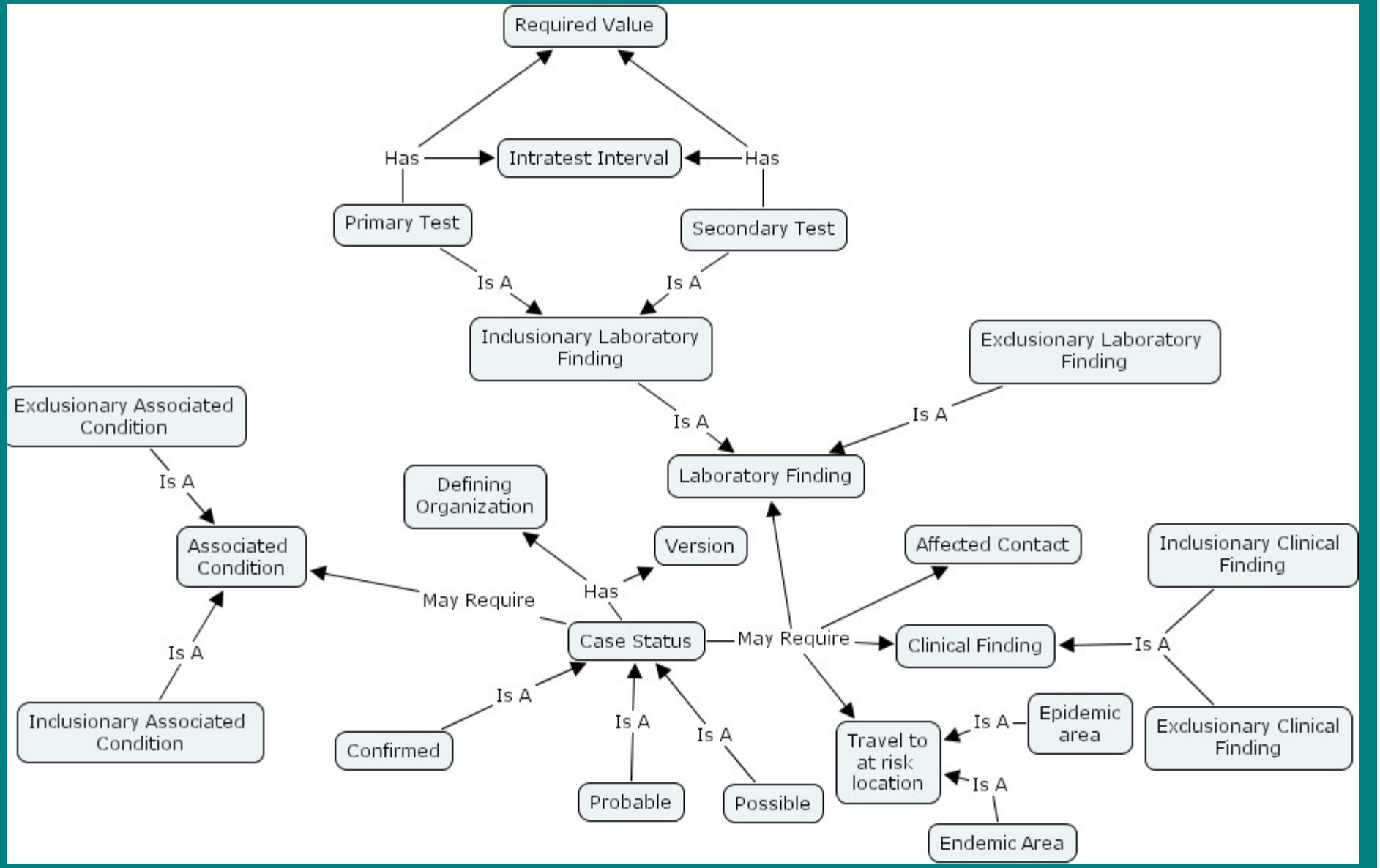
Define the domain

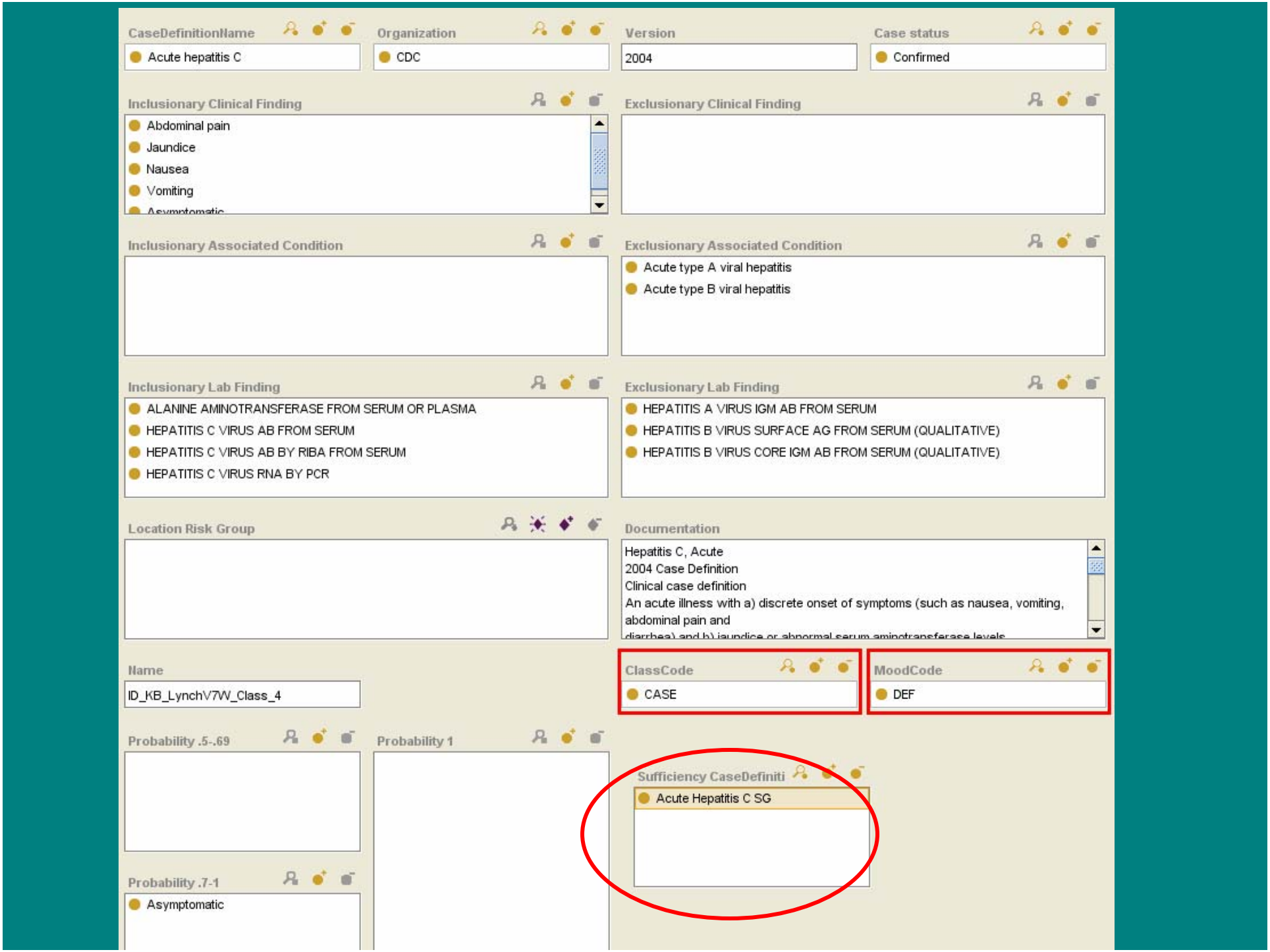
- Domain was selected as the infectious diseases nationally reportable as well as those reportable in CA, HI and Utah
- Select a subset of these to define rules based on the case definition that covered a diverse set of conditions

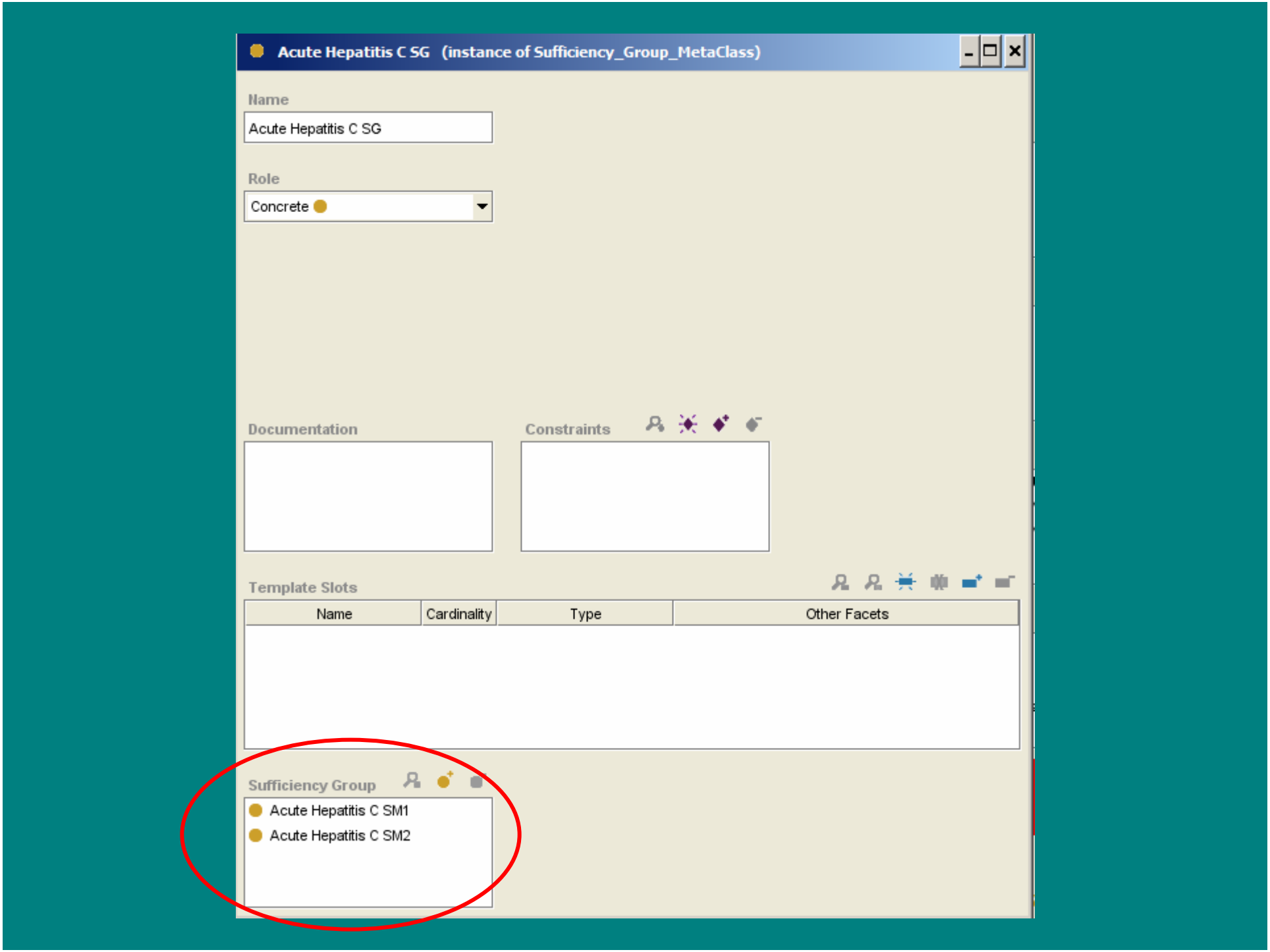
The Big Model

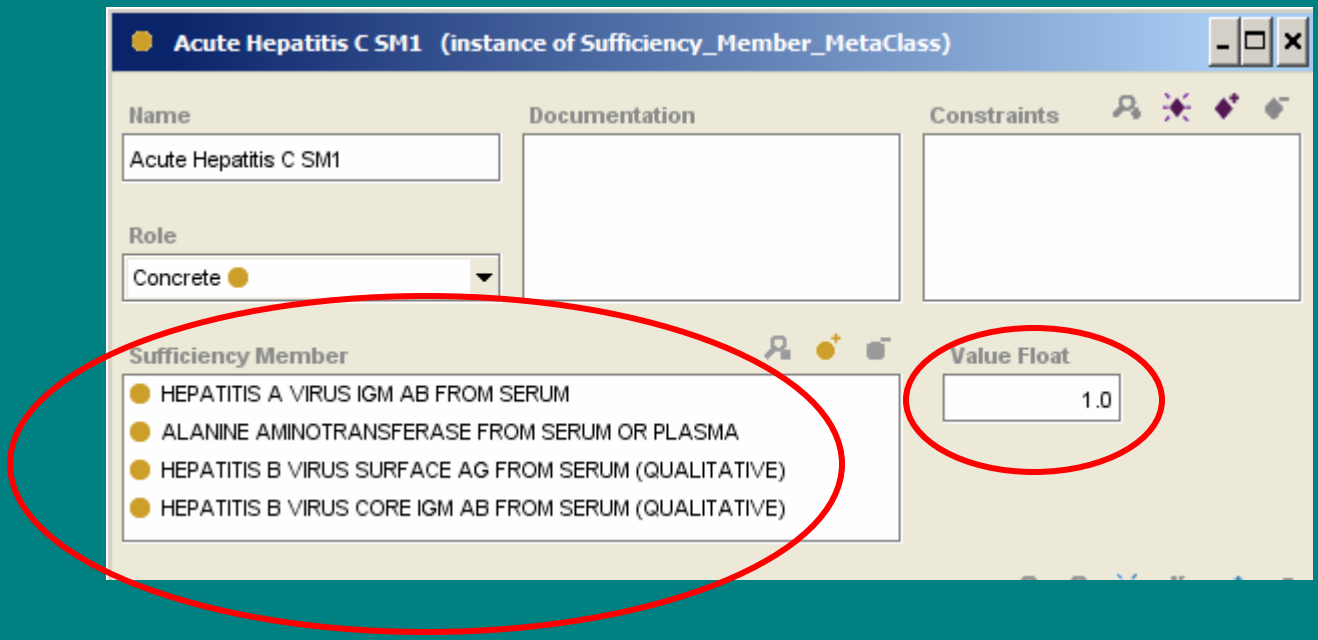


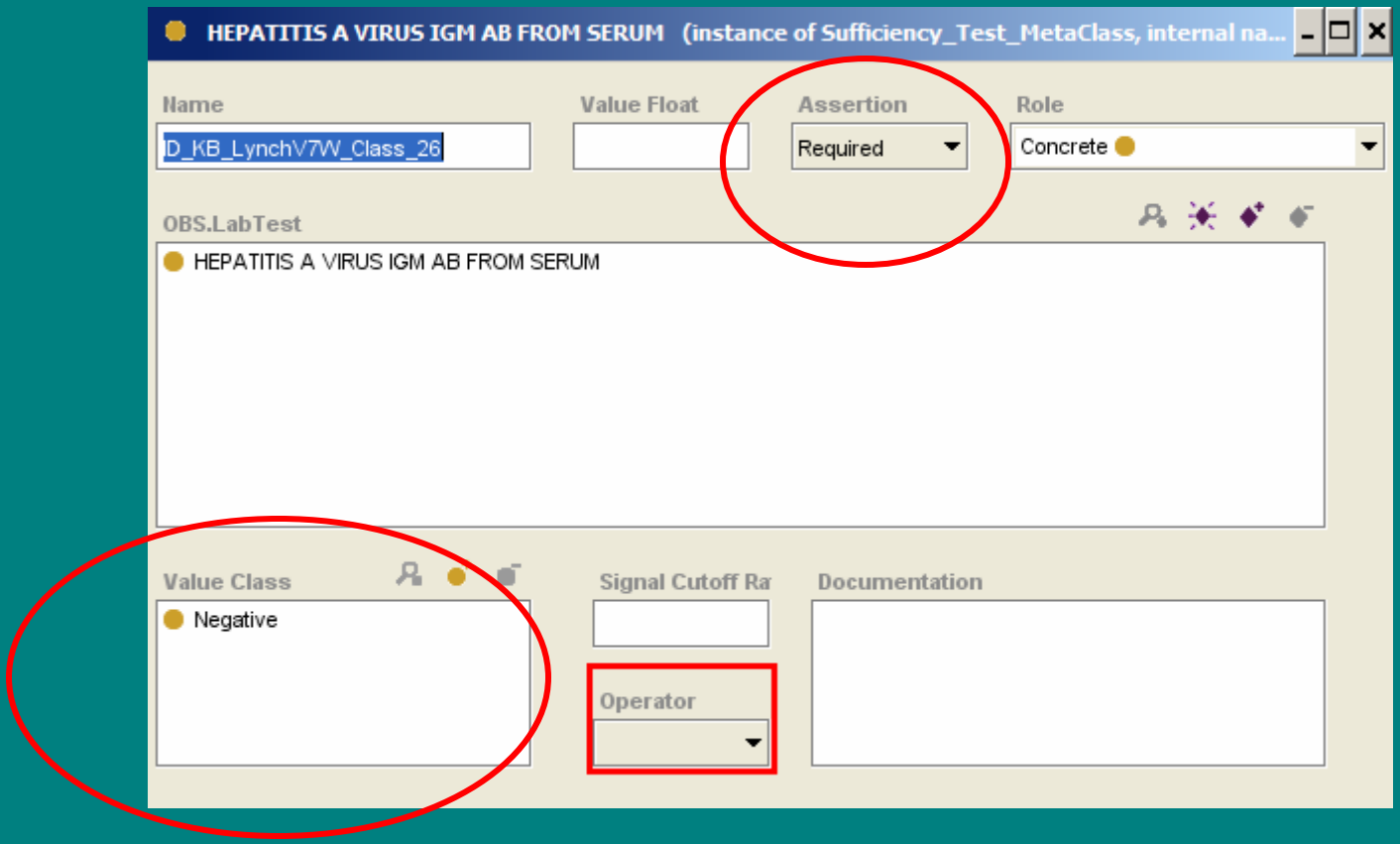
The Case Definition Model



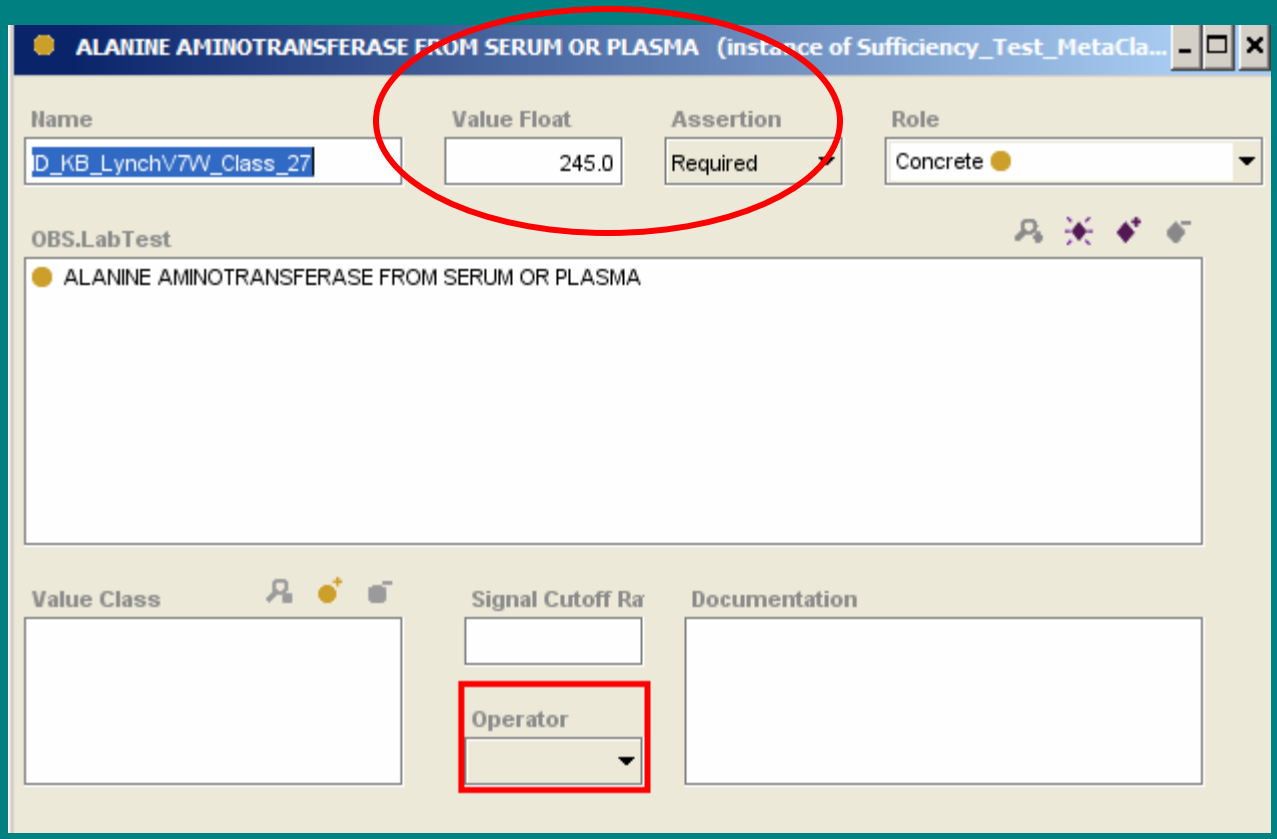

CaseDefinitionName
Acute hepatitis C
Organization
CDC
Version
2004
Case status
Confirmed
Inclusionary Clinical Finding
Abdominal pain
Jaundice
Nausea
Vomiting
Exclusionary Clinical Finding
Inclusionary Associated Condition
Exclusionary Associated Condition
Acute type A viral hepatitis
Acute type B viral hepatitis
Inclusionary Lab Finding
ALANINE AMINOTRANSFERASE FROM SERUM OR PLASMA
HEPATITIS C VIRUS AB FROM SERUM
HEPATITIS C VIRUS AB BY RIBA FROM SERUM
HEPATITIS C VIRUS RNA BY PCR
Exclusionary Lab Finding
HEPATITIS A VIRUS IGM AB FROM SERUM
HEPATITIS B VIRUS SURFACE AG FROM SERUM (QUALITATIVE)
HEPATITIS B VIRUS CORE IGM AB FROM SERUM (QUALITATIVE)
Location Risk Group
Documentation
Hepatitis C, Acute
2004 Case Definition
Clinical case definition
An acute illness with a) discrete onset of symptoms (such as nausea, vomiting, abdominal pain and
Name
ID_KB_LynchV7W_Class_4
ClassCode
CASE
MoodCode
DEF
Probability .5-.69
Probability 1
Sufficiency CaseDefiniti
Acute Hepatitis C SG
Probability .7-1
Asymptomatic


Acute Hepatitis C SG (instance of Sufficiency_Group_MetaClass)
Name
Acute Hepatitis C SG
Role
Concrete
Documentation
Constraints
Template Slots
Name
Cardinality
Type
Other Facets
Sufficiency Group
Acute Hepatitis C SM1
Acute Hepatitis C SM2


Acute Hepatitis C SM1 (instance of Sufficiency_Member_MetaClass)
Name
Acute Hepatitis C SM1
Documentation
Constraints
Role
Concrete
Sufficiency Member
HEPATITIS A VIRUS IGM AB FROM SERUM
ALANINE AMINOTRANSFERASE FROM SERUM OR PLASMA
HEPATITIS B VIRUS SURFACE AG FROM SERUM (QUALITATIVE)
HEPATITIS B VIRUS CORE IGM AB FROM SERUM (QUALITATIVE)
Value Float
1.0


HEPATITIS A VIRUS IGM AB FROM SERUM (instance of Sufficiency_Test_MetaClass, internal na...
Name
D_KB_LynchV7W_Class_26
Value Float
Assertion
Required
Role
Concrete
OBS.LabTest
HEPATITIS A VIRUS IGM AB FROM SERUM
Value Class
Negative
Signal Cutoff Ra
Documentation
Operator

Different Tests – Different Results



Use and Integration with the Knowledgebase Ontology

- Vocabulary Service
- Correlation of laboratory tests and clinical observations to conditions
- Eventually to derive questions for investigation
- The evidence-based reasoning tool
- Extracts Case Definitions
- Populates Sufficiency groups
- And derives goal driven reasoning facts

Evidence Based Reasoning

- The core product of electronic surveillance is acquisition and use of data during the investigative process
- Critical to the use of artificial intelligence applications is the consistency and interoperability of information

Use of the Knowledgebase within the PHS3 Core Product

As a vocabulary service

To Derive observations

Correlate Lab Tests w/Conditions Sets

Define CDC Case Definitions

Derive clinical questions to meet case definition

To reason about non-Identified conditions

Current Work in AI

- Evidential Reasoning
  - **Case Definition (Today's topic)**
  - Case Triage
  - Driving Task and Data Collection

Evidence Framework

- Data Endorsement
  - Source
  - Type
  - Accuracy
- Rule Endorsement
  - Exact/Sufficient
  - Supportive
  - Necessary
  - Hard Not
  - Detracting
- Conclusion
  - Case Status Setting
  - Support Required
  - Tasking, Data Collection
- Procedural Evidence
  - Schedule Tasks and perform tasks to acquire further belief
- Inference Types
  - Model Based Reasoning
  - Causal
  - Correlational
- Task Endorsement
  - Confirmatory
  - Corroborate
  - Conflict
  - Potential Conflict
  - Redundant

Using Evidence For Building Case Definitions

- What is required to confirm a case
- What does our current data (Lab and Clinical Findings) support
- What is needed to confirm that case

Sufficiency

- Sufficiency Group
  - Abstracts the case definition from the KB Ontology
  - Defines the holistic view of the evidence required to set case status based upon the case definition
  - Provides the reasoning framework for inferring case status
  - Provides the reasoning framework for goal driven scheduling of data collection

Sufficiency

1. The condition or quality of being sufficient.
2. An adequate amount or quantity.

The sufficiency of evidence to adequately support the case definition

Sufficiency Group

```
(deftemplate Sufficiency-Group
    (slot          Group-id)
    (slot          condition)
    (slot          status)
    (slot          case-id)
    (multislot     sufficient-list)
    (multislot     required-list)
    (multislot     necessary-list)
    (slot          necessary-count))
```

Acute Hepatitis C Sufficiency Group

Required

- 22327-1 HEPATITIS C VIRUS AB FROM SERUM
  - 10828004 positive

One of the following Necessary:

- 51599-5 HEPATITIS C VIRUS AB BY RIBA FROM SERUM
  - 10828004 positive
- 5012-0 HEPATITIS C VIRUS RNA BY PCR
  - 10828004 positive
- ALANINE AMINOTRANSFERASE FROM SERUM OR PLASMA
  - Value: 245.0 > Greater than

Exclusionary Evidence:

- 5195-3 HEPATITIS B VIRUS SURFACE AG FROM SERUM (QUALITATIVE)

Clinical Findings

- Supportive
  - 18165001 Jaundice
  - 73879007 Nausea
  - 15387003 Vomiting
  - …

Structure of Backward Chaining

- (Evidence-Needed
  - Sufficiency Group id
  - Case id
  - Clinical Finding or Lab Test
  - Result Value
  - Evidential Support)
- Allows for Goal Driven Questions
  - What do I need to support this hypothesis
  - Which can be translated into questions for data collection and tasks within a workflow

Lab Test / Clinical Observation

- (deftemplate LabTestResultObs
  - (slot resultType
  - (slot LabTestName
  - (slot LabTestCode
  - (slot testResultStatus
  - (slot resultInterpretation
  - (slot organism)
  - (slot value)
  - (slot valueRangeLow)
  - (slot valueRangeHigh)
  - (slot referenceRangeLow)
  - (slot referenceRangeHigh)
  - (slot operator)
  - (slot valueClass)
  - (slot valueOrdinal)
  - (slot usedForStatus)

(deftemplate ClinicalObs
- (slot resultType
- (slot ClinicalObsName
- (slot ClinicalObsCode
- (slot valueClass)
- (slot usedForStatus)

Acknowledgements

- This general approach to modeling the case definition in Protégé arose from work started by Tim Doyle in EPO and assisted greatly by Haobo Ma and Sigrid Economou of the CDC.
- Support and advice has been provided by Samson Tu at Stanford University.
- My colleagues at CA DHS have provided content and feedback.